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GEOGRAPHIC INTELLIGENCE REPORT

MANGANESE IN BRAZIL

CIA/RR-G-6

CENTRAL INTELLIGENCE AGENCY

Office of Research and Reports

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MANGANESE IN BRAZIL

Summary

Manganese available for export is currently found in three major areas of Brazil. (1) The Amapá Territory north of the Amazon River has deposits that are being actively developed by the Bethlehem Steel Corporation; (2) the Morro do Urucum deposits near the Bolivian border will be developed by the United States Steel Corporation as soon as negotiations are settled with the Brazilian Government; and (3) the Minas Gerais complex of manganese mines includes the dwindling deposits of Morro da Mina, mined by U.S. Steel for over 30 years. Since these manganese sources are of critical importance to United States stockpiling of strategic materials, the problems connected with their development are significant.

The lack of adequate transportation facilities in Brazil has retarded exploitation of natural resources throughout the country and is a dominant factor in the processing of manganese ore in every location. From Urucum, transportation is possible by either river or rail, but there are several obstacles to overcome. A new railroad is under construction for transportation of the Amapá ore to the new port of Santana on the Amazon, where connections will be made with ocean-going cargo boats. Rail transportation facilities from the manganese mines in Minas Gerais have been inadequate and undependable to such an extent that trucks are now being used to transport

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ore to Rio de Janeiro for shipment, even though the roads are in many ways unsatisfactory.

The possibilities of sabotage to the manganese mining industry in Brazil are reduced by the utilization of open-pit methods at most mines; underground mining at Morro do Urucum presents greater hazards. All transportation facilities could be rendered inoperable for short periods. Evidence from past situations indicates that most serious threats of sabotage would be immediately investigated by the Brazilian Government.

I. Introduction

A. The Importance of Brazilian Manganese

The manganese deposits of Brazil rank high among the resources that give that country a significant position both in the Western Hemisphere and in the world. The importance of these resources to the steel industry of the United States, for both domestic and defense needs, has in recent years become particularly outstanding. Since each ton of ingot steel contains about 13 pounds of ferromanganese, which is refined from as much as 40 pounds of manganese ore, millions of tons of ore are required in U.S. steel production. Brazil's enormous manganese deposits can provide much of this ore.

Brazil is one of the world's five leading manganese-producing countries, the others being the USSR, the Gold Coast, the Union of South Africa, and India. With by far the largest reserves in the

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Western Hemisphere, Brazil proved during World War II to be an important source of supply when other channels were cut off. The development of a large continuing market for Brazilian manganese has been hampered only by poor internal transportation facilities and a lack of technical knowledge. As the USSR withdraws as a source of manganese ore, however, Brazil's supply again assumes increasing importance. Explorations and investigations since 1945 have opened up new opportunities for exploitation, making reserves readily available which are comparable to any elsewhere in the world. Their proximity to the United States brings them into focus as a logical source for the stockpiling requirements of materials strategic to our security.

Between 1901 and 1949, Brazil exported 10,522,034 metric tons of manganese ore, of which 8,121,198 tons came to the United States. The bulk of this ore was from the state of Minas Gerais, with only a small amount coming from other states, principally Bahia and Mato Grosso. Innumerable manganese mines, large and small, have been developed in south-central Minas Gerais during the last 50 years. A few of these are still producing high-grade ore, but many have been exhausted, depleting the reserves most accessible to the industrial centers in the southeastern part of the country.

A question has arisen regarding the wisdom of exporting ore that may be needed for domestic purposes. Although limited deposits exist in the state of Bahia and other scattered localities, none are

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so advantageously located for Brazilian use as those in Minas Gerais, and a sentiment against the export of these reserves is developing in Brazil.

B. New Manganese Deposits

Fortunately for both Brazil and the United States, new reserves have been discovered, or rediscovered, in two widely separated sections of Brazil, neither of which is well situated to supply the Brazilian market. In 1946, new deposits giving promise of over 10,000,000 tons of ore were found in the tropical rain forests of Amapá, north of the Amazon. Located 3,200 miles from Baltimore, this area is the most easily accessible to the United States and least so to the Brazilian steel center at Volta Redonda. The Bethlehem Steel Corporation is operating these deposits as a 49-percent participant with the Brazilian firm that first initiated development, the Cia. Indústria Comércio e Minérios, Ltda. (ICOMI).

In another remote section of Brazil, in the southwestern part of the State of Mato Grosso about 20 miles from the Bolivian border, are the extensive manganese reserves of Morro do Urucum, believed by some to be the largest single deposit of high-grade manganese ore in the world. At least 27,000,000 tons are estimated to be available there, with the possibility of additional workable deposits in adjacent mountains. These deposits, though known for many years, have been productive only since they were taken over by the Sociedade Brasileira da Mineração, Ltda. (SOBRAMIL), in 1941. Since 1948, the

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United States Steel Corporation has been negotiating with the Brazilian Government for rights to develop the mines with SOBRAMIL, but to date no agreement has been reached. Because the area lies within the restricted 150-kilometer (90-mile) zone around Brazil, which is legally prohibited to foreign investors, there are difficult legal and political problems.

This area, while far distant from the United States, is more than 1,000 miles farther from Brazil's steel industries than are the Minas Gerais mines, and the Morro do Urucum ore is therefore more suitable for export purposes. The deposits are approximately 1,350 miles from Volta Redonda by rail. For a picture of the relative distances between the deposits and possible destinations of the ore, see Map No. 11666.

C. Vulnerable Aspects of the Brazilian Manganese Industry

Brazilian manganese mining is not acutely susceptible to damage from sabotage, but production could be interrupted to a considerable extent. Open-pit methods at most of the mines in Minas Gerais, as well as at the Amapá deposits, reduce the opportunities for destruction of equipment. The underground mining operations at Urucum could be more easily disrupted.

Transportation facilities in Brazil are vulnerable in many respects. It has been reported that there are no trained guards to protect the rights-of-way of either Federal or State railroads. Signaling and dispatching are done manually on all lines, and could

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easily be tampered with. In the mountainous areas between the coast and the interior plateau in southeastern Brazil, there are large numbers of bridges, tunnels, and narrow cuts on both railroads and roads. Damage to them could easily disrupt traffic seriously for extended periods. In the vast stretches between Corumbá and the more populated parts of the State of São Paulo, many grades and cuts along the Noroeste line could be rendered inoperable, and the complex system of bridges and culverts near the Paraguay River offers several opportunities for sabotage.

Port facilities are more carefully controlled in Rio de Janeiro and Santos. At Ladário, on the Paraguay River, a unit of the Brazilian Navy provides protection. Company precautions both at Urucum and Amapá can be initiated at the outset of large-scale operations.

From information available, it is probable that army and navy units could control most threats of sabotage. Strong government action, judging from incidents in the past, could handle any Communist-inspired strikes in Brazil. Such a development, however, at an Argentine port through which ore might be shipped could delay movement of ore for extended periods, if no alternative shipping means were planned.

D. Scope of Report

This report discusses in detail the physical situation and problems at the Amapá and Urucum deposits, which are the potential large-scale producing areas of Brazilian manganese for export.

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The situation as described at each conforms with the plans proposed for the development of these areas; actual construction and mining operations may, of course, vary in some details. The Minas Gerais and Bahia areas are considered only briefly, in order to complete the picture of Brazilian manganese, since exports from these mines are rapidly dwindling.

II. Minas Gerais Deposits

The oldest known deposits of manganese in Brazil are in a section of the State of Minas Gerais abounding not only in manganese but also in iron, gold, silver, quartz crystals, bauxite, and a variety of other important minerals. Manganese deposits were first discovered in this area in 1888, during construction of the Central do Brasil railroad, but actual shipments were not made until 1894, from the Usina Wigg development. The most notable mine of all, Morro da Mina, was opened in 1904 near the town of Queluz (now called Conselheiro Lafaiete) and has been producing on a large scale ever since. Dozens of other properties have been developed over the past 5 decades. Many of these have been exhausted and abandoned, but some have continued to produce or are capable of further development.

Few mines, however, have large reserves of high-grade ore left. Selective mining for manganese ore of exportable grade (46 to 48 percent Mn) has removed a large proportion of the best ore, and that remaining in many places will require treatment to put it on the competitive market. Estimated total reserves of only 1 million tons

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remain in the 13 properties owned by the Cia. Sidurgica Nacional, which owns and operates the Volta Redonda steel mill. Of these, only the Agua Preta and Cocuruto mines, with a capacity of 70,000 to 75,000 tons per year, were operating in 1950 (see Map No. 12627).

Low-grade ore occurs in the São João del Rei district, at the Nazaré, Cachoeira, and Penedo mines among others. Other mines credited with production in recent years include the Jurema, Engenha, São Gonçalo, and Saúde. Plans for development of new deposits are frequently reported to the American Embassy in Rio de Janeiro, but owing to inadequate transportation facilities and services, there is difficulty in establishing profitable operations at most of these mines. Until the railroad systems of Brazil are considerably improved, development of many of the country's natural resources will be restricted.

The Saúde deposits, located about 5 miles southeast of Dom Silvério, which is on the meter-gauge Leopoldina Railroad, were said in 1948 to be potentially as significant as Morro da Mina. Subsequent developments, however, have proved disappointing, the reserves being estimated now to be about 1 million tons. A high iron, silicate, and alumina content makes it necessary to concentrate the ore before it can be exported. The Mineração Geral do Brasil, Ltda., owned by the Jafet Brothers, has been operating the mine and shipping ore for treatment to their blast furnaces at Mogi das Cruzes in São Paulo over both narrow- and broad-gauge lines of the Central do Brasil

Railroad. Alternate routes require a combination of roads with railroads. Transportation facilities accessible to the mine area at present are not the most advantageous, and economical development is severely handicapped.

The outstandingly successful Morro da Mina mines were taken over in 1920 by the Cia. Meridional de Mineração, Ltda. (a Brazilian subsidiary of U.S. Steel), which has operated the mine continuously ever since. During that time over 4,500,000 tons have been exported, and in 1943 an equivalent amount was estimated as still in reserve. More recent estimates place total reserves at about 1 million tons.

The mine is located in mountainous terrain at an elevation of 3,650 feet. The region has a subtropical climate, with a short rainy season between November and March. Temperatures are never extreme, and living conditions are pleasant. Labor is readily available.

The ore bodies occurred originally at the top and along the sides of a hill, in somewhat overlapping lenses which have been mined by open cuts after the overburden was removed. Much of the original mountain has been cut away (Figure 1). All work was done by hand until mechanized equipment was adopted within recent years (Figure 2). Decauville cars move the ore within the mine area and dump it directly into chutes that load rail cars on a spur that runs 4 miles to the main line of the Central do Brasil Railroad. The spur and the main line are both broad gauge (1.6-meter). Until 1952,

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ore was taken straight through on the Central lines to stockpiles or dock-loading facilities in Rio de Janeiro (Figure 3).

Rail transportation over this line has deteriorated so rapidly in recent years, however, that shipments of manganese ore were virtually at a standstill in 1951. Because of limited rolling stock, the Central do Brasil claimed its cars were needed to serve domestic industrial needs. Whatever the real reason, repeated efforts on the part of U.S. Steel representatives had little effect, and 50,000 fewer tons of manganese ore were shipped from the mine in 1951 than in 1950. The problem was solved by shipping ore from the mine to Rio in a fleet of 50 company-owned trucks, which carry 10,000 tons a month a distance of 275 miles, much of it over hazardous mountain roads.

Since most mining in the Minas Gerais region is of the open-pit type and much of the work is done by hand, damage to equipment from sabotage would be at a minimum. Mechanized facilities could be rendered inoperable, however, which would cause delays of several days. Sabotage along the railroad lines and roads, where tunnels, steep grades, narrow cuts, and bridges might require extensive repairs, could cause longer delays.

Although dock facilities in Rio de Janeiro could be seriously damaged, they are more easily guarded and could be more rapidly rebuilt than facilities in less populated areas.

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III. Bahia Deposits

Manganese is being produced today in two areas in Bahia. Although the deposits in that state are far smaller than those in Minas Gerais, they have provided a limited source of exportable manganese and can continue to supply domestic needs to some extent. (See Map No. 12627.)

The deposits that have been worked the longest are those near the village of Santo Antônio de Jesus, about 16 miles west of the town of Nazaré on the Jaguaripa River. The Sape, Onha, and Pedras Petras mines there have been operated intermittently for 50 years and are gradually being depleted. Under the operation of the Cia. Minas da Bahia, production was at a standstill in 1950 because of financial difficulties. Ore from the mines is transported by branch lines to the meter-gauge Nazaré Railroad, which carries it to stockpiles on the dock at São Roque, where it is loaded on boats.

The second active manganese district in Bahia is in the Jacobina area on the Viação Ferrea Federal Leste Brasileiro, northwest of Salvador. The Sociedade Importadora Exportadora, Ltd. (SIMEL) is actively operating there and small amounts of ore are being produced. In 1951, 4,674 tons of ore were shipped to the United States from São Roque and 7,580 tons from Salvador.

Since production is small, the probabilities of sabotage are slight.

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IV. Morro do Urucum Deposits Near Corumbá

The Morro do Urucum area in the State of Mato Grosso is reputed to contain the largest single manganese deposit in the world. Although they are farthest from the United States of all the Brazilian deposits, the Morro do Urucum mines are of sufficient magnitude to warrant development as a future source of manganese. (See Map No. 11666.) Known for more than 50 years as a rich reserve, this area has been in active production for scarcely more than 10 years. U.S. Steel is currently negotiating with the Brazilian Government for permission to participate in development operations with the Sociedade Brasileira da Mineração, Ltda.

Underground mining methods will be used, and the ore will be shipped either by rail through Brazil to the port of Santos or by boat down the Paraguay River to a transshipment point, probably in Uruguay. Several problems arise in connection with each of these routes.

Pending settlement of an agreement between U.S. Steel and the Government of Brazil, the Export-Import Bank of Washington is considering a loan of $30,000,000 for the development of the Morro do Urucum mines.

A. Geographic Location and Description of the Region

Located close to the geographic center of the South American continent, the Morro do Urucum manganese deposits are at approximately 19°20'S, 57°40'W, in western Brazil about 15 miles south of the town

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of Corumbá, State of Mato Grosso. Twenty miles to the west of the Morro do Urucum is the Bolivian border, and 15 to 25 miles to the north, east, and southeast, the Paraguay River swings in a wide curve as it flows southward toward Paraguay (Figure 4). The town of Corumbá, with a population of about 20,000, is the commercial center for a large area of southern Mato Grosso. Located on the west bank of the Paraguay, it is a scheduled stop for river traffic moving from farther north to the Río de la Plata, 1,700 miles to the south. (See Map No. 12627.)

The region is divided into three distinct physiographic areas: (1) the river, with its broad flood plain known as the Pantanal; (2) a plateau, which extends westward into Bolivia for many miles; and (3) a cluster of mountainous masses, the remnants of an ancient and elsewhere eroded upland. The Morro do Urucum (Urucum Hill) is one of these, rising about 2,600 feet above the adjacent river flood plain, or up to 3,000 feet above sea level. On its slopes are exposed strata of high-grade manganese ore.

The hydrógraphy of the region differs markedly from section to section. Many streams and lakes occur in the Pantanal in conjunction with the complex Paraguay River, creating a dense drainage pattern which inhibits the easy development of transportation routes. At the end of the rainy season, which lasts from December through February, the river itself in places is tens of miles wide, although in the dry season its width is only 1,000 feet at Corumbá. On the plateau,

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streams are much less numerous, flowing from a few springs on the mountain slopes.

The climate is generally pleasant and healthful. Annual rainfall is 49 inches (based on an 11-year record), with decided seasonal variations. The winter months -- June, July, and August -- are the driest. The rainy season lasts through the summer months (December, January, and February), and temperatures and relative humidity are at times very high. Periods of extreme heat do not last long, however, especially at the elevation of the mine site. In the winter, cold south winds are frequent, frost occasionally occurs, and in the mountains ice sometimes forms over shallow water.

Dense hardwoods that grow on the hillsides wherever water is available provide sufficient timber for structures at the mines and for charcoal where it is needed for fuel. Reforestation with eucalyptus can provide timber of adequate size within 6 years, and such a program will become essential if large quantities of timber are needed on a continuing basis. On the plateau, vegetation is restricted to thorny trees and cacti typical of semiarid tropical country. During the dry season, when the river and streams are low, the Pantanal supports a stand of good pasture grass.

B. Description of the Deposits

Two economically significant beds of manganese have been found in the Morro do Urucum. A third, which lies between these two, is not sufficiently thick to be of economic value. The same

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manganiferous strata occur in the Serra da Santa Cruz to the southeast, but upon investigation they appear to be so located and so thin that their exploitation is not feasible at present. Their existence, however, gives evidence that other nearby mountains of the same geological series may be potential sources of manganese.

Morro do Urucum is a long mesa with a higher, rounded northern end, roughly 2 miles long and 1-1/2 miles wide; the elevation of its highest ridges is between 2,800 and 3,000 feet (Figure 5). The ore bodies are estimated to contain over 27,000,000 metric tons of 46-percent manganese ore, with some estimates running as high as 40,000,000 tons. Two parallel seams of manganese occur at varying elevations between 2,000 and 2,600 feet (Figure 6). The lower seam, called Bed No. 1, averages about 7 feet in thickness, with 16-1/2 feet the maximum reported. Bed No. 2, about 120 feet above No. 1, averages 4 feet in thickness. Both beds dip 5° to 12° into the mountain, the formation being an irregular syncline. However, no mining difficulties are expected to develop from so slight a dip, and it has been speculated that the beds may flatten almost horizontally within the mountain. Between 500 and 900 feet of overburden covers the beds in most cases, necessitating underground mining methods instead of open-pit operation.

A detailed geological interpretation of the deposits with an analysis of various samplings tested is given in U.S. Geological Survey Bulletin No. 946-A, Manganese and Iron Deposits of Morro do

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Urucum, Mato Grosso, Brazil, by John Van N. Dorr II, 1945. Although not up to date in many respects, this report gives a technical presentation of the ore bodies and contains a wealth of valuable background information.

C. Transportation and Shipping Facilities

Corumbá is accessible at present by boat, air, and rail. No all-weather roads connect the area with major centers of activity in Brazil or surrounding countries. There is regular north-south boat traffic on the Paraguay River, and scheduled flights include Corumbá on transcontinental routes as well as connecting with Cuiabá, capital of the State of Mato Grosso, and Asunción, capital of Paraguay. On 31 January 1952 the last segment of the Noroeste Railroad was completed between Corumbá and Bauru, where connections are made en route to the port of Santos. Until that date the 70-kilometer (43.5-mile) stretch between Pôrto Esperança and Corumbá was still under construction, necessitating river or road connections for that part of the trip.

The completion of the railroad makes possible alternate routes for the transportation of Urucum ore. Up to the present, all ore has been towed on barges down the Paraguay for transshipment at an Argentine port, usually Rosario. This method of shipment, however, has its disadvantages. The mines are located approximately 1,700 miles upstream from an ocean port, whereas the distance by rail to the port at Santos is only 1,135 miles. Furthermore, if a port on the Río de la Plata estuary is used, another 1,000 miles of ocean transport is required in addition to the distance between Santos and the United States. Additional inconvenience is occasioned by the dominant influence of Argentine shipping companies over the lower Paraná, which amounts to a near monopoly of river traffic. High dock fees and unnecessary redtape make Argentine ports increasingly undesirable, and a more satisfactory transshipment point in Uruguay is probably the best solution. The construction of a proposed steel mill in Argentina, at San Nicolás on the Paraná, will further complicate the problems of river traffic, since iron ore for the mill will be obtained in the Corumbá area also and will have to be transported over the same route.

Navigation on the Paraguay and Paraná Rivers presents few complications. Travel is restricted to daylight, because channels have never been adequately marked, but rock shoals and sand bars are the only hazards and these are well known to river pilots. A small dredging operation is considered adequate to keep a 7- to 10-foot channel open for most of the year. Reports on present conditions vary, but shipping by heavy barges is known to be possible at least 250 days a year. Freight rates via the river are estimated to run about $6 per ton to Montevideo, assuming a return cargo of supplies to Corumbá and the mining area.

Rail shipment from the mine to the port of Santos would be by the Noroeste Railroad as far as Bauru and the Sorocabana Railroad for the remaining distance. Both are meter-gauge lines. An alternate route through Campinas and São Paulo would necessitate transshipment to Cia. Paulista and E.F. Santos a Jundiaí lines, both of which are 1.6-meter gauge.

Although the distance from the mines to the port is some 500 miles less by rail than by river and could be covered 3 to 4 times as fast, rail transportation of the ore has serious drawbacks. The Noroeste Railroad, for the western two-thirds of its length, has lightweight rails and a poor roadbed and is inadequately maintained. Existing facilities are scarcely adequate for even small shipments of ore, and would be completely inadequate under full-scale production.

The increased traffic resulting from the movement of quantities of manganese ore would necessitate reconstruction of much of the roadbed and replacement of many miles of track. In addition, new rolling stock would have to be added to that already available. The expense, equipment, and time involved in providing adequate service for the continuous movement of the ore by rail are discouraging from the investor's point of view. Freight rates would probably run as high as $12 a ton. Although this route is favored by the Brazilian Government because of the additional revenue that the country would acquire, it is doubtful that it would prove to be a workable plan from all points of view.

Whether the ore is shipped to an ocean port by rail or by river, it must be transported from the mines to a loading platform or dock. Previous operations have used trucks on a steep roadway from the level of Bed No. 1 down to the plateau and north to barge-loading docks near Ladário on the Paraguay River. Plans for the proposed operations, however, specify an aerial tramway from the mines to a railroad siding at the base of the mountain. This form of transportation is estimated to be the most economical, since it would cost less to build and maintain than either a new, graded roadbed or an inclined railway over the rough terrain. As planned, the 2.4-mile tramway will start at the loading bins near the mine portal where ore is received from the mine cars. Conveyor bins will travel down the tramway and unload at the other end into a bin over ore cars on the rail siding, which will be connected with the main line of the Noroeste by a half-mile spur line.

If transportation to the port is to be over the Noroeste and Sorocabana Railroads to Santos, the ore cars will be loaded at the tramway terminal. If transport is to be by river barge, bottom-dump ore cars with diesel locomotives will take the ore to stockpiles at the dock area near Ladário, where the ore will be dumped from a trestle onto stockpiles having a potential capacity of 70,000 tons. Hoppers, loaded from belt conveyors, will then move the ore to a cross belt, which will load it onto barges waiting at the immediately adjacent dock.

D. Development of the Mines

Morro do Urucum was known as a source of manganese and iron ore as early as 1870, but the first active development was initiated in 1906 by the Compagnie de l'Urucum, which represented Belgian steel interests. This group drove several adits into the main bed on the north and west slopes of the mountain, constructed an inclined runway for getting ore to a stockpile at the base of the mountain, built a railroad from there to Corumbá, and opened several miles of road. Close to 7,000 tons of ore were mined and stacked before the market collapsed after World War I. It is believed that no ore was shipped.

No further action took place at Urucum until 1940, when the Sociedade Brasileira da Mineração, Ltda. (SOBRAMIL) obtained a concession from the State of Mato Grosso, which possesses title to the site. Since that date roads have been rebuilt, loading facilities have been constructed, and mining has been resumed in the lower bed. Twelve tunnels have been opened and extended 20 to 40 feet into the mountain. Shipment of ore was begun in 1941, starting with the stockpiles left by the Belgian company over 20 years before. The ore averages 47 to 48 percent manganese. Shipments amounted to 10,000 tons in 1941, 25,000 tons in 1942, and 8,000 tons in 1943. Since that date production has slackened, but it can be expected to resume as soon as negotiations regarding operations are concluded.

Beginning in 1948, the U.S. Steel Corporation became interested in the Corumbá deposits as a potential replacement for their diminishing reserves in Minas Gerais. Transactions were begun with the State of Mato Grosso and the Chamma Brothers, who owned and operated SOBRAMIL. In 1950, after the U.S. Government became interested in stockpiling manganese from Brazilian deposits, further negotiations were initiated regarding a loan through the Export-Import Bank of Washington to get the mines operating on a large scale. Since that time, complications in the dealings with the Brazilian Government, the Mato Grosso Government, and the Chamma Brothers have delayed a conclusion. It is anticipated that a decision will be reached soon whereby U.S. Steel, controlling 49 percent of the company, will operate the mine and supply the U.S. Government with 3,000,000 tons of manganese over a 12-year period.

Pending settlement of the negotiations, the Oliver Iron Mining Co. in 1948 contracted to survey the area and submit plans for large-scale operation of the Urucum deposits. (These plans were supplemented in 1950.) If these proposals are followed, a series of mines will be developed which, with adaptations, will conform to the longwall retreating system used in coal mining. A typical operation is described below.

Beginning operations 120 feet below present Tunnel 4 (in the lower outcropping of ore), a haulage adit penetrating eastward 600 feet into the mountain would reach Bed No. 1. At this intersection with the ore, a raise would be run back to the surface along the dip of the ore bed and directly above the adit and would reach the surface at or near the entrance of Tunnel 4. At right angles to this raise, levels would be run about 150 feet apart. In this particular section of the mountain, levels running to the north as far as 1,500 feet would come out in the face of a cliff; those driven south could be stopped at any desired point and the ends connected by a raise that would then be carried out to the surface. The good ventilation thus provided throughout the mine would permit the use of diesel engines instead of electricity for which generators would have to be provided. Vertical raises would also be put up from the haulage adit to each level above, making it possible to drop the mined ore from each level to ore cars in the adit below.

With this arrangement of raises and levels, all ore can be handled downhill and any water encountered will flow out of the mine by gravity. Stoping would start at both ends of each level, retreating toward the raises, through which ore would be moved out of the mine.

Upper Bed No. 2 could be mined at the same time by running a vertical raise up to it from the original haulage adit. Raises and levels would then be run in the same way as those in Bed No. 1. The upper bed should be mined a little in advance of the lower one, to prevent settling of the lower bed and possible resultant shifting higher up.

The operation described will produce at least 1 million tons of ore. Since the ore body extends over an area of more than 2 square miles, several mines of this type will be developed.

By terracing an adjacent ledge on the northwest side of the mountain, an extensive camp capable of accommodating several hundred employees can easily be developed. Water available in springs nearby can be pumped into a storage reservoir higher on the mountain.

E. Labor Supply

Local labor is available for the development of the Urucum mines. Corumbá, a town of about 20,000, with Ladário and other nearby villages, is a good source of unskilled labor. Skilled labor will be much more difficult to obtain, and any special training will have to be done on the job. The modern mining methods to be utilized will create conditions more desirable than those to be found in many other Brazilian mines, however, and the work should appear attractive.

F. Vulnerability to Sabotage

Considerable damage could be inflicted on the mine workings at Urucum by sabotage. Mine shafts, in particular, and the aerial tramway could be sufficiently damaged to cause extensive delays in operations.

In the event that river transport is used, transportation facilities from the base of the tramway to the dock area could be interrupted for short intervals, as could service at the dock itself. Considerable inconvenience could also be caused by damage to the fleet of boats carrying the ore. The possibility of subversive influences stemming from the Río de la Plata area is fairly high, and the free movement of persons from Argentina, Paraguay, and Bolivia along the river makes surveillance difficult.

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If rail transport is used, precautions along the entire length of the Noroeste line will be essential. Numerous bridges and culverts in the Río Paraguay region present an abundance of vulnerable points, as do many areas along the route farther east. Protection of the railroad in sparsely populated areas would be difficult. The Sorocabana line from Bauru to Santos enters the coastal mountain area, and the steep grades, bridges, and cuts provide opportunities for serious injury to the line.

The dock facilities at Santos, as at Rio, would be subject to considerable damage, but they stand a better chance of being protected or repaired than do many other facilities which, if sabotaged, would hamper production as much.

V. Serra do Navio Deposits in Amapá

The most promising Brazilian manganese deposits from the point of view of availability to the United States are those near the Amazon River in the Federal Territory of Amapá. Located deep in tropical rain forest, these deposits were only recently recognized to be of great potential value. Mineral ores were known to be present in the area as early as 1934, but it was not until 1946 that an analysis of samples was made and the deposits were recognized to contain high-grade manganese ore.

Despite the inaccessibility of the region and surveying difficulties, a concession was soon granted to the Sociedade Indústria e Comércio de Minérios, S. A. (ICOMI) of Belo Horizonte. Progress since

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then has been rapid, and full-scale production is anticipated by 1955 or 1956. Since 1949, the Bethlehem Steel Corporation has been a 49-percent participant in the undertaking, assuming operational and management control until a loan of $67,500,000, made by the Export-Import Bank of Washington for development purposes, has been liquidated.

A. Geographic Location and Description of the Region

The Amapá manganese -- generally referred to as the Serra do Navio deposits -- is located on the banks of the Amaparí River in the municipio of Macapá, about 130 miles north of the Amazon River, at approximately 1°N, 52°10'W. (See Map No. 12515.) Surrounded by dense rain forest in rough terrain, this isolated area was until recently known only to occasional prospectors who penetrated the jungle from the open savannah country south of the Araguarí River. There were no settlements immediately adjacent to the mine site, the only inhabitants of the region being clustered in a few small villages along the rivers that constitute transportation lines inland from the coast. This section of Brazil did not achieve the status of território until 1943, when it was separated from the sparsely settled State of Pará; prior to that time, little economic development had taken place.

Not the least of the drawbacks to settlement was the hot humid climate, characteristic of the Amazon lowlands close to the Equator. The mining area itself has the advantage of being at an elevation of

300 feet, which makes it somewhat cooler than Macapá, on the Amazon, approximately at sea level. Data gathered over the past few years show a maximum temperature of 86°F and a minimum of 68°; the average is about 75°F, with a maximum daily range of 18°. Rainfall is heavy, the average annual precipitation being about 80 inches. The heaviest rains occur from February through June, and the lightest in September through November. The storms are usually violent and accompanied by heavy winds, the seasonal variations being in frequency and duration. Relative humidity is high, requiring precautions in the care of all equipment, clothing, food, and household goods.

Although long-term data have not been collected, the conditions described are judged by natives to be normal, with occasional cycles of slight change to be expected.

B. Description of the Deposits

Outcroppings of manganese ore occur in a belt of hills and bluffs half a mile wide, extending in a northwest-southeast direction for about 5 miles along the Amaparí River (Figure 7). The greatest concentration of deposits is in the southeastern part of the zone. Ore bodies are irregular in character, breaking through the surface of the ground in at least 25 major places with unpredictable underground extensions. The areas between outcroppings have proved to be barren in many instances. Float ore, ranging in size from pebbles to enormous blocks, occurs throughout the area. The largest single ore body known is 450 meters (1,450 feet) long, and the longest

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stretch of closely spaced or connected ore bodies is about 1,100 meters (3,350 feet). The deepest ore has been determined to be within 40 to 50 meters (125 to 150 feet) of the surface, and in some places sheer cliffs of ore rise as high as 20 meters (60 feet). Open-pit operations will therefore prove practical, without much stripping. Samples tested give evidence of an average manganese content of at least 45 percent.

The deposits have been divided into the following three groups for the sake of convenient reference (see inset on Map No. 12515):

1. Clemente area, west of the Amaparí:
   F-1) Clemente
   F-2)

   Serra do Navio Camp on the river bank

2. Chumbo area, across the Amaparí to the east:
   C-1) Chumbo
   C-2)
   C-3 Janot
   C-5 Baixio

3. Terezinha area, extending southeast and roughly paralleling the east bank of the river:
   A-3 Autunes, and Autunes camp
   A-2 Forno
   A-1 Cançao
   T-5 Observatorio
   T-1 Macaco
   T-2 Gruta
   T-3 Gurita
   T-8 Baixinho
   T-9 Glycon
   T-4 Curuça) South Terezinha, with Terezinha camp
   T-6 Padeiro)
   T-10 Sentinela #1
   T-11 Sentinela #2

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C. Transportation and Shipping Facilities

Transportation to the ore zone at present requires a combination of services. Air connections exist between Belém (Pará) and Macapá. Three to four trips a week are scheduled via Cruzeiro do Sul Airlines and one a week by a Brazilian Air Force cargo-passenger plane, the 210-mile trip taking about an hour and 20 minutes. In addition, river boats make several trips a week between Belém and Macapá, with numerous stops en route. The trip upstream to Macapá averages 60-70 hours, and the return trip downstream to Belém, 55-65 hours. The Territory of Amapá operates its own shipping line, SERRTA, which carries bulk freight as well as passengers and maintains a more or less regular schedule. At present the river route follows the southern estuary of the Amazon, from Belém around the south and west sides of Marajó Island. For full-scale ore shipment in the future, it is expected that the northern estuary will be charted and marked for the safe navigation of ore boats.

From Macapá a good gravel road traverses the open, rolling savannah for 120 kilometers (72 miles) northwest to Pôrto Grande on the Araguarí River (Figure 8); the trip requires about 2 hours. At the company landing, Pôrto Platon, 2 kilometers (1.2 miles) west of Pôrto Grande, outboard motor launches and cargo canoes continue the trip to the mining area by following the Araguarí River 8.1 miles to its junction with the Amaparí, which in turn is followed upstream for another 61.6 miles to the Serra do Navio camp. The journey upstream takes 6 to 8 hours, whereas the return trip can be made in 4 to 7 hours if conditions are favorable. Considerably more time may be required under some circumstances; one source quotes 18 to 20 hours upstream and 7 to 9 downstream. The rapids in the river have a great influence on the trip, the duration of which depends on the water level at different seasons, the size of the boat and load, and the power of the motor used. At one of the worst points in the 4-mile-long Cachorrinho Rapids -- 48 miles above Pôrto Platon -- the depth at low water at times does not exceed 2 feet, although at high water as much as 8 feet have been recorded. Shallow-draft boats are now transporting limited quantities of ore during favorable periods, but it can readily be seen that large craft could never be relied upon for the transport of large shipments under full production, even to Pôrto Platon. Below Pôrto Grande, cataracts prevent river traffic from following the Araguarí to the Atlantic Ocean, making it essential to divert all transport overland south to the Amazon.

Ore shipment eventually will be made by rail, upon the completion (scheduled for 1954) of the railroad which was to have been started by Foley Bros. of Pleasantville, N. Y., before the end of 1952. This line will carry crushed ore from its terminus, which will be centrally located in the mining area, to the new port (Santana) being developed on the north shore of the Amazon, about 12 miles upstream from the town of Macapá. Returning cars will haul commercial freight and camp supplies.

Preliminary surveys, run by Foley Bros. in 1951, followed the existing gravel road north to Pôrto Grande on the Araguarí River rather than cutting more directly across country toward the mine sites. This route was considered preferable because it crosses fewer rivers and less rugged country, and also it makes possible the use of river transport on the Araguarí and Amaparí Rivers to the mine area until the northern portion of the railroad is completed.

Approximately 212 kilometers (127 miles) of standard-gauge (1.435 meters), single-track line is to be laid, of which 126 kilometers (75 miles) will be across the open savannah and 86 kilometers (52 miles) in the jungle. Three major river crossings along the route will necessitate steel bridges having a combined length of 310 meters (1,023 feet) (see Map No. 12515), as follows:

(1) Rio Cupixi, 100 miles from Santana

(2) Rio Amaparí, 117 1/2 miles from Santana

(3) Chivet Creek, 122 miles from Santana

Two minor trestles, at Cachorrinho Creek and Sentinela Creek, and several relief trestles will be built of timber. Maintenance shops will be constructed at the port site and at the mines, with essential section houses along the line. At present, Foley's construction camp is established at Pôrto Platon.

All heavy construction materials will be shipped from the United States. Timber is available locally for most needs, and sources for the necessary ballast and concrete aggregate are to be found along the route. The proposal for construction requirements of the line was based on an estimate of 20-car trains, each car carrying 50 tons of ore. Annual production of 500,000 tons of ore would thereby require 2 trains a day, or if production were raised to 1,000,000 tons per year, 4 trains a day.

The need for an ore-loading station on the Amazon led to the development of a new port site. The only established port in the vicinity is at the town of Macapá, which is unfortunately located at a place where the river bottom slopes from the shore so gradually that a jetty 450 meters (1,450 feet) long is required to reach out to a depth of 4 meters (13 feet). Upstream about 12 miles, however, the island of Santana (4 miles long) narrows one channel of the river to approximately 600 meters (2,000 feet) and a maximum depth of about 50 meters (165 feet), with the 9-meter (30-foot) depth required by the proposed ore boats located quite close to the north shore. In addition, the island affords protection for the port site against winds from the south.

Immediately adjacent to the ore-loading site on the east is a new dock area for Macapá, being built by the território government to improve its own shipping services. Both ports are connected with Macapá by a road 32 kilometers (19 miles) in length, which also connects with the road between Macapá and Pôrto Grande.

Proposed plans for all ore-loading facilities at the new port of "Santana" were submitted in 1950 by the engineering firm of Moran, Proctor, Freeman, and Mueser of New York. (See inset on Map No. 12515.) These plans were based on an anticipated delivery of 560,000 tons of ore per year with possibilities of expansion to 1,120,000 tons per year. The ore will be transported the 210 kilometers (127 miles) between the mine site and the port in bottom-dump cars, which will empty into a track hopper and then move onto a siding. Standing room for two loaded trains and one empty will be provided by sidings and switches, permitting continuous dumping operations and transfer of cars without interruption. As an alternative, the main track will run onto the dock, where servicing can be accomplished by a 50-ton derrick directly between a waiting vessel and the adjacent cars.

Plans call for ore cars about 25 feet long, with a capacity of 50 to 55 tons each. These will dump into the track hopper, which has a holding capacity of 170 tons of crushed ore, and will be so arranged as to permit the dumping of two ore cars simultaneously. The ore will then be drawn off by a 36-inch belt conveyor, which will deliver it to a stacking conveyor. Ore will be stockpiled with a traveling turntable-type stacker, having a swinging boom conveyor 36 inches wide by approximately 60 feet long. This stacker will be able to place 45,000 tons of ore on each side of its 500-foot track, and 84,000 tons more could be overcast by a power shovel, making a total storage capacity of 174,000 tons.

Reclaiming ore for transfer from the stockpiles to boats will be done by the power shovel or the boom conveyor on the stacker. Either of these can load the ore into a traveling hopper, from which it will move to the boats via conveyor belts and a shuttle conveyor on the dock. With all equipment utilized, the maximum loading rate will be about 2,500 tons an hour.

The pier, as shown on the inset on Map No. 12515, with dolphins extending upstream and downstream for mooring and moving of boats, is located to provide a minimum of 30 feet of water at mean low tide, which will accommodate 10,000-ton ore boats. Ore carriers of 25,000 tons capacity may be used unless sand bars at the mouth of the Amazon prohibit their passage. It will be necessary, however, to construct additional dolphins farther out in the river where the depth is at least 40 feet.

Associated facilities at the loading site will include a diesel-engine generating plant, storage tanks, powder magazines, repair shops, locomotive service sheds, warehouses, office buildings, and staff quarters. Fresh water will be obtained from wells.

D. Development of the Mines

Development of the mining property has progressed steadily since 1946, when some clearing was done, trails were cut, and the general extent of the deposits was delimited by the Território. Extensive exploration of the area began in 1947, when ICOMI contracted with the Amapá Government to develop the ore bodies. In June 1949, after some temporary construction and minor ore production, ICOMI reached an agreement with Bethlehem Steel Corporation whereby the latter acquired a 49-percent interest and agreed to undertake the extensive exploration and the engineering necessary for a large-scale mining operation.

Intensive geological mapping and 27,000 feet of diamond drilling in 168 locations throughout the deposits produced results which by October 1951 established a minimum reserve of at least 10,600,000 tons of ore, probably of 46 percent or higher manganese content. The basis of this estimate is as follows:

	Tons
Lode ores, calculated from diamond drilling.	9,177,000
Lode ores, undrilled and outlying bodies	849,000
Float ores, next to or on top of ore body outcrops	327,000
Float ores, flanking or at some distance from outcrops.	320,000
	10,673,000

Upon the realization of this potentiality, full-scale operations got under way to develop the area, requiring detailed planning for mining installations, living accommodations, power and water supplies, transportation facilities, and associated needs.

Two main camps had been established during preliminary workings: one at Serra do Navio on the west bank of the Amaparí, and the other at the South Terezinha deposits at the southeast end of the ore zone. A loading station, Terezinha Landing, also built early on the east bank of the river near the Terezinha deposits, will continue to be used. Subsequent developments have led to the selection of an area

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near the Gurita deposit as the permanent center for all activities, and plans for the town of Vila Terezinha were drawn up.

By December 1951, plans were laid out for a 3-year program that would allow for the development of facilities needed at various stages during the construction of the railroad. Facilities that would aid in preliminary mining activities and that could be easily constructed were to be installed early. Certain installations which would be essential to full-scale mining and which would enable operations to commence as soon as the railroad was open, were to be constructed immediately regardless of transportation difficulties or cost. On the other hand, those that could be dispensed with until later were postponed until the completed railroad could provide transportation for needed equipment.

Preliminary estimates called for the completion of the railroad in 1954, although at present a later date appears to be more realistic. In the interim, all goods must be transported via road and river, which requires scheduling of barge trips during high water and of cargo canoes during low water in order to keep the necessary supplies moving.

Power will be provided by diesel generators, the oil for which will probably be obtained in the Caribbean and stored in tanks both at the port site and at Terezinha Village. A reservoir behind a dam on Cancao Creek adjacent to the village will provide water for both domestic and mining needs.

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Ore bodies T-3, T-4, T-5, and T-6, in the Terezinha group, are the only deposits currently being developed. Ore is now broken by hand, but by the time the railroad is finished foundations for a crushing plant will be completed, and crushing facilities, conveyors, ore bins, and associated installations will be erected as soon as equipment can be shipped in.

E. Labor Supply

The unskilled labor supply has been adequate, workers being available from both Macapá and Belém, as well as from among the migrants who have drifted to the lower Amazon from the drought-stricken northeastern states of Brazil. The supply of skilled workmen, on the other hand, is very limited; probably they will have to be sought from more distant cities, and considerable training in the use of equipment will be necessary. About 400 Brazilians are currently employed in the mines. The attitude of the workers is one of cooperativeness and good nature, which contributes greatly to the solution of problems arising from local conditions. Health facilities are good, with a doctor stationed at the camp and a 70-bed hospital and trained staff available in Macapá.

F. Vulnerability to Sabotage

The open-pit methods to be employed at the Amapá deposits will deter sabotage in the mining areas. Considerable inconvenience might be inflicted on water supply, power generators, and other facilities at the settlement areas, but production would not be seriously affected.

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The most serious destruction could probably occur along the railroad, at the bridges and trestles, where considerable time would be required for repair.

Dock facilities, being separate and operated by the company, should be fairly easy to guard. The general situation in the Amapá area, where all the mining facilities are new and under close control and which is in a section of the country where subversive influences are slight, is such that there is less opportunity for sabotage than in any of the other manganese-producing regions in Brazil.

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APPENDIX A

Gaps in Intelligence

Information is fairly complete on manganese which is mined in Brazil for export. Reports of very recent developments on major problems are not always received promptly, but most of the information significant for the purposes of this report was obtained. The Urucum negotiations, in which decisions are pending, and the unsatisfactory situation regarding shipment by the Central do Brazil Railroad reflect internal political maneuvers which are not entirely understood, even by reporting officers in Brazil.

Reporting on mining methods and production in the numerous small mines in Minas Gerais is not at all up to date; therefore such information as was available served primarily as a guide. The variable nature of these operations makes it nearly impossible to keep detailed reporting up to date.

Large-scale maps with accurate mining data are not available, but a current TCA (Technical Cooperation Administration) field survey in central Minas Gerais will provide much information suitable for future compilations on that area.

Information on physical security measures in specific mining and transportation operations is notably lacking.

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APPENDIX B

Sources and Evaluation of Sources

1. Evaluation of Sources

The best source materials available for this study were the technical reports prepared under contract by the commercial firms that were asked to prepare specifications for various aspects of developmental operations.

Intelligence reports from CIA, Army, Navy, and Air Force sources provided details of work progress as observed by reporting officials. U.S. Foreign Service despatches have been valuable for interpretations of the negotiations between U.S. firms and Brazilian interests.

Substantive reports prepared by various agencies in Washington all provided good background information. Each contributed significant interpretations of the manganese situation as of the date of the report, although numerous misstatements have become apparent in the light of subsequent information.

2. List of Sources

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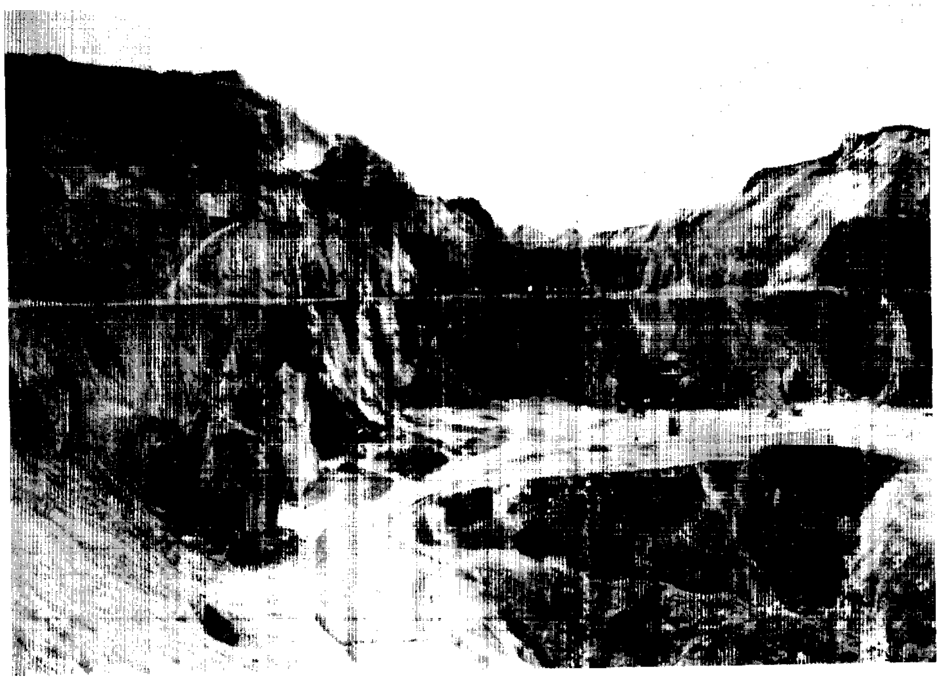

Figure 1. Morro da Mina Mine, near Lafaiete, Minas Gerais, Brazil. 1945.

Figure 2. Loading manganese ore preparatory to shipment by rail, Morro da Mina Mine, Lafaiete.

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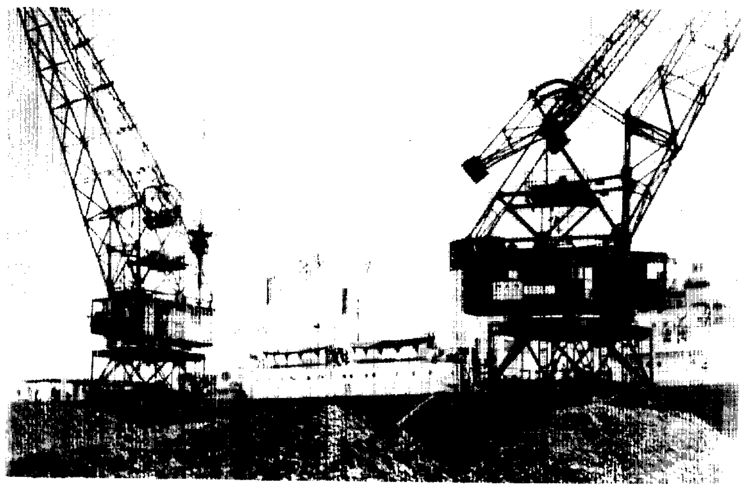

Figure 3. Loading manganese ore, port at Rio de Janeiro. 1945.

Figure 4. Paraguay River near Corumbá, Mato Grosso, Brazil; cases of mining equipment and oil drums in foreground.

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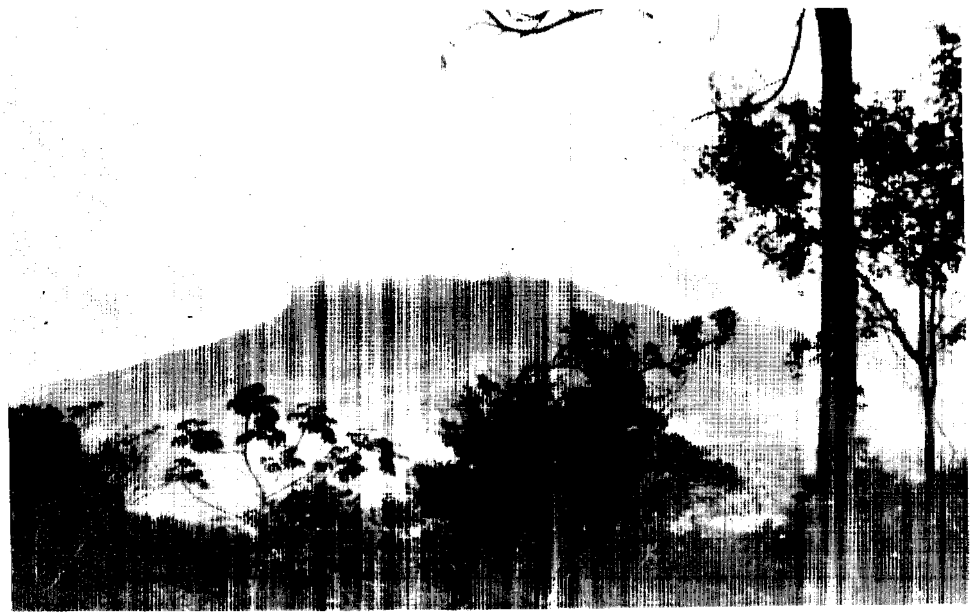

Figure 5. Morro do Urucum, near Corumbá, Mato Grosso, Brazil.

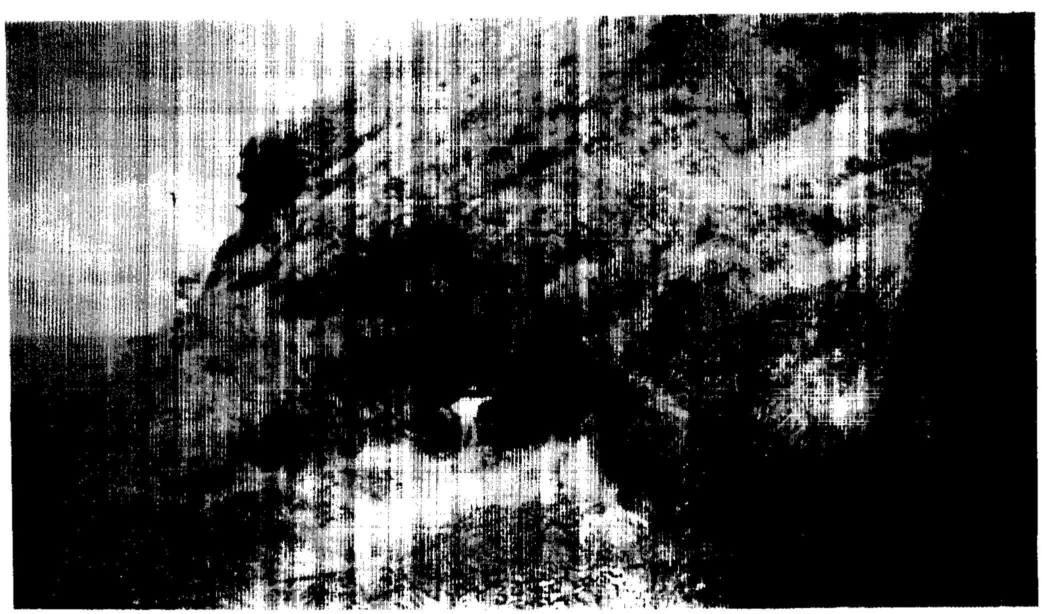

Figure 6. Outcropping of manganese ore, Morro do Urucum, Mato Grosso, Brazil.

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Figure 7. Chumbo Outcrop of manganese ore on the Amaparí River, Amapá Territory, Brazil.

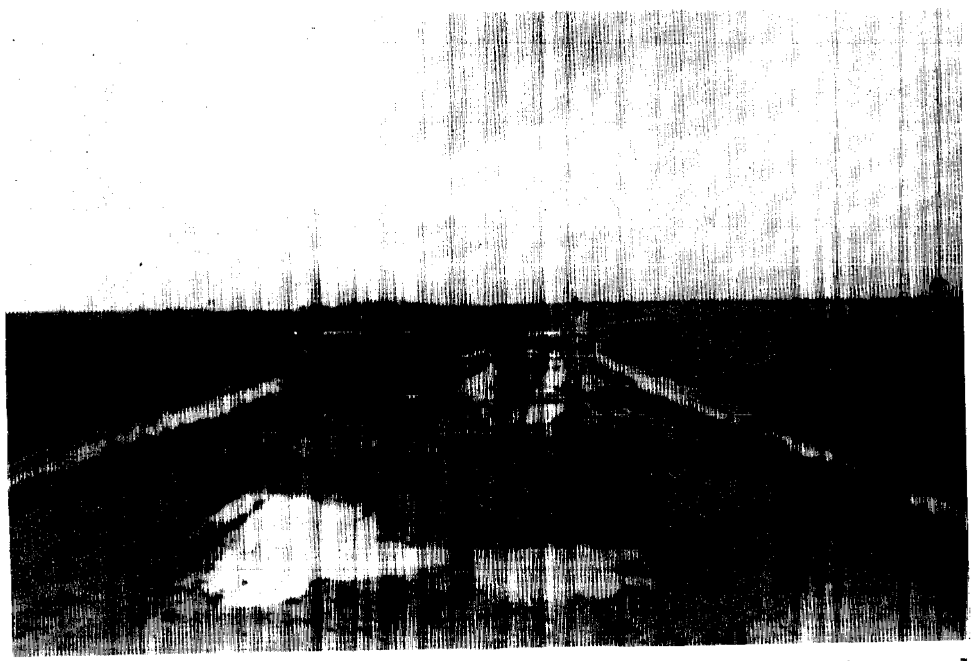

Figure 8. Typical flat country between new port of Santana and the Araguarí River, Amapá Territory, Brazil. Road is now considerably improved.

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BRAZIL
MANGANESE DEPOSITS

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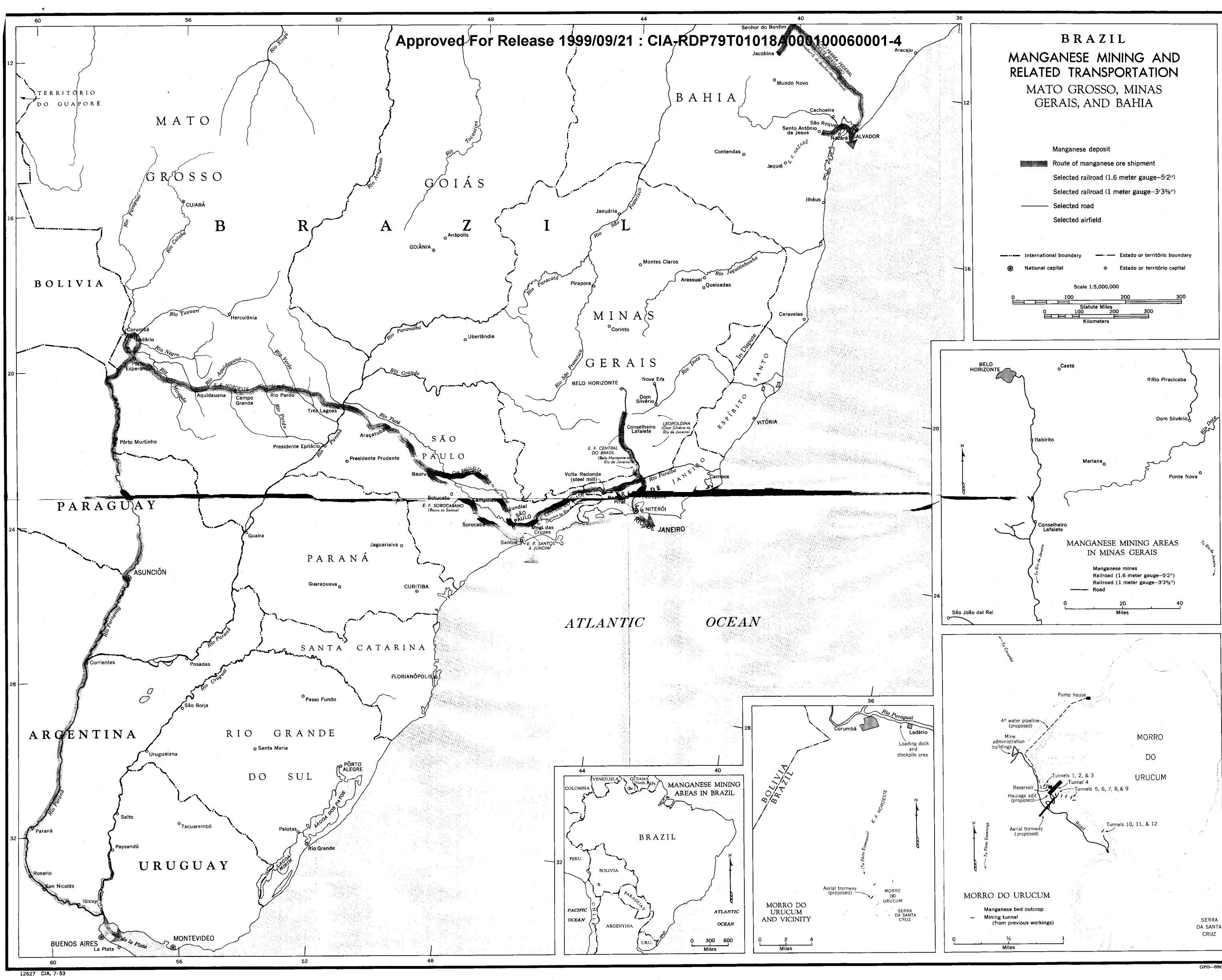

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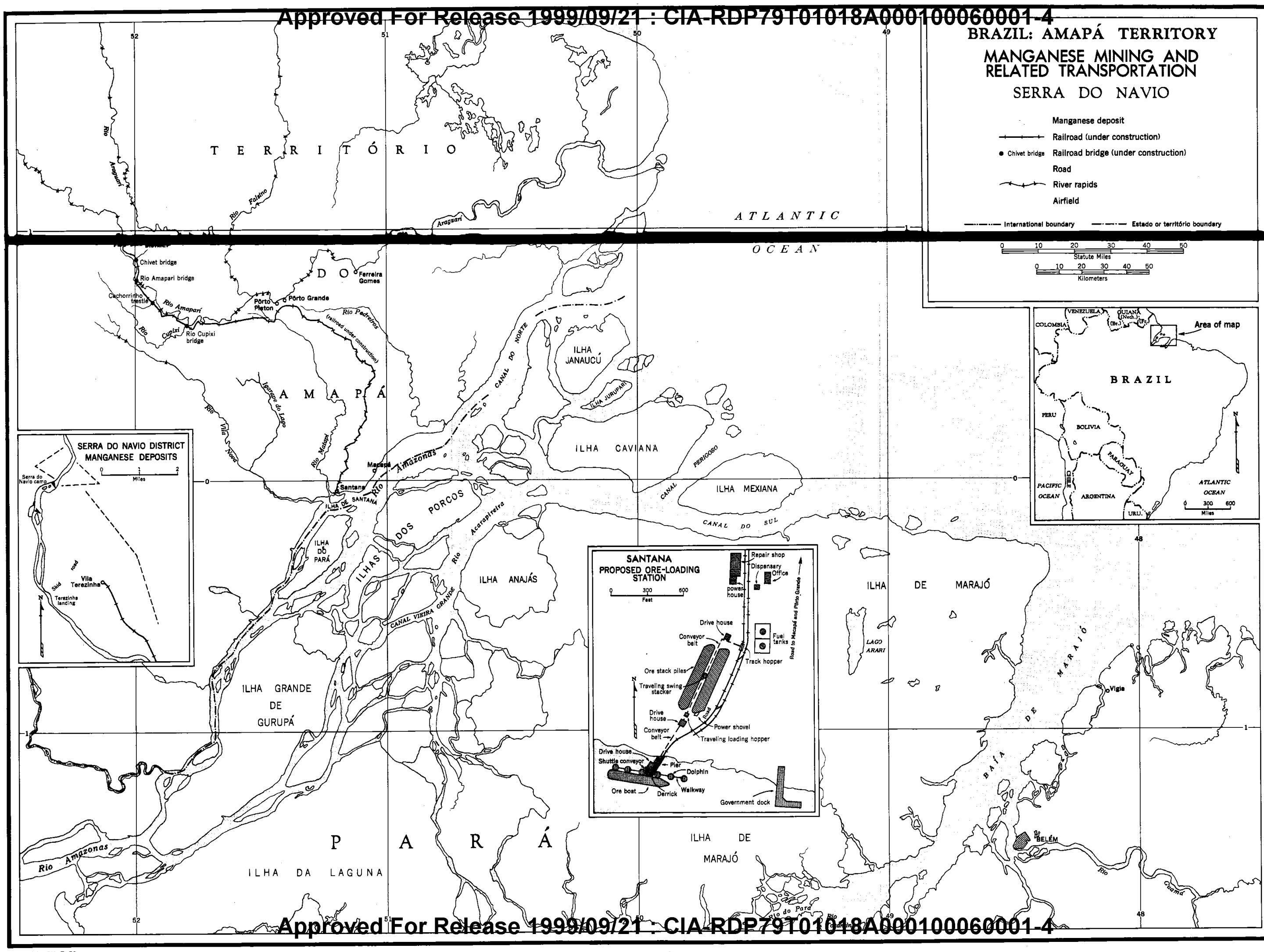

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